COMPARISION AND SIMULATION OF RESIDUAL STRESSES IN CASTINGS

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ABSTRACT

Two individual high-pressure die-casting geometries were developed in order to study the influence of process parameters and different alloys on the distortion behaviour of castings. These geometries were a stress lattice and a V-shaped sample tending to form residual stress due to different wall thickness respectively by a deliberate massive gating system.

In the experimental castings the influence of the most important process parameters such as die temperature and die opening time and the cooling regime was examined. The time evolution of process temperatures was measured using thermal imaging. The heat transfer coefficients were adapted to the observed temperature distributions.

Castings were produced from the two alloys NICU30FE, EN AC-44300 alsi12 fe. The distortion of the castings was measured by means of a tactile measuring device. For the alloy AlSi10MnMg thermo-physical and thermo-mechanical data were obtained using differential scanning calorimetric, laser flash technique, dilatometer and tensile testing at elevated temperatures. These data were used for modeling the material behavior of the NICU30FE, EN AC-44300 alsi12 fe alloy in the numerical model while for the alloy. literature data were used. Process and stress simulation were conducted using the commercial FEM software ANSYS Workbench. A survey on the results of the comparison between simulation and experiment is given for both alloys.

In this project we are doing material optimization to increase the bonding strength for two materials. here 3D model designed in CATIA V5 R20 software and analysis done on ANSYS software.

1. INTRODUCTION

The die casting process is one of the net shape manufacturing techniques and is widely used to produce high production castings with tight tolerances for many industries. In the die casting process molten metal is injected under high pressure into a die cavity through the runner and gating system. This high pressure is applied via the plunger mechanism. A toggle system is required to hold the two halves of the die closed during molten metal ejection and intensification. Castings are the final products of the die casting process, and care must be taken to guarantee their quality. A quantitative understanding of the stress distribution and the deformation pattern of parts produced by die casting will result in closer tolerances to the part design specification, a better die design and eventually to more productivity and cost savings. To achieve these objectives the casting and the dies have to be studied together as an integrated system. This will enable practitioners to more accurately predict the deformation of the part in the final form using analytical tools and to modify the die and parting surfaces based on the simulation results so that a dimensionally sound product will result.

1.1 Casting:

Casting processes have been known for thousands of years, and have been widely used for sculpture (especially in bronze), jewellery in precious metals, and weapons and tools. Traditional techniques include lost-wax casting (which may be further divided into centrifugal casting and vacuum assist direct pour casting), plaster mold casting and sand casting.

2. LITERATURE REVIEW

Dantzig [1] explained in details the development of thermal stresses in metal casting. In his research finite element analysis was used to solve the modeling problem numerically. The finite element model was explained step by step in conjunction with the constitutive equations. The model was created for homogeneous, isotropic, material deformed under plane strain conditions.

Smelser and Richmond [2] studied the effect of the constitutive model on stresses and deformations. The application was on a solidifying circular cylinder made of pure aluminum. A finite element model was built and the finite element code ABAQUS was used to solve it. The thermal part of the model was designed based on temperature measurements.

N. Zabras et al [3] built a finite element model to be used in simulating continuous or ingot casting process of pure aluminum. This model is limited to castings of axial symmetry or plain strain casting conditions. In this model the thermal and mechanical analyses are uncoupled.

K.C. Wang, et al [4] used both finite difference and finite element methods to analyze the thermal stresses formation in sand casting of cast iron. FDM was used to compute the temperature distribution in the casting, while the FEM was used to predict the thermal stresses depending on the temperature results. The cast iron properties were given as a function of temperature.

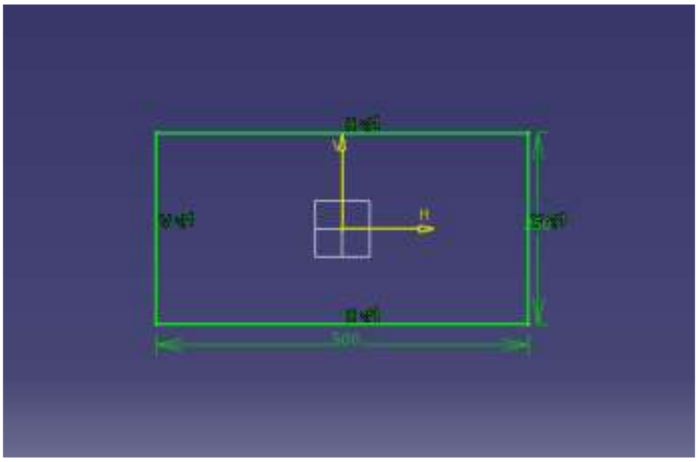
R. N. Parkins and A. Cowan [5] ran several experiments to study the mechanism of residual stress formation in sand casting. The experiments were run for different alloys.

3. INTRODUCTION TO CATIA:

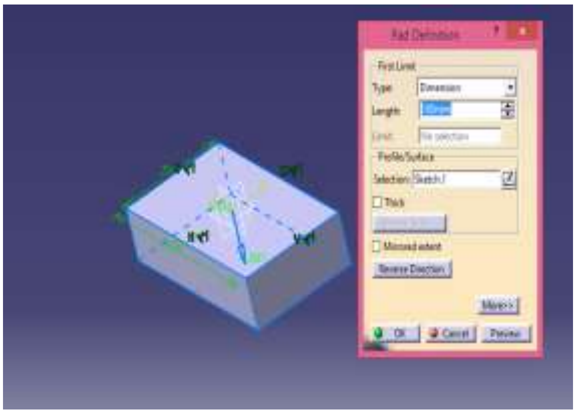
CATIA (Computer Aided Three-dimensional Interactive Application) is a multi-platform CAD/CAM/CAE commercial software suite developed by the French company Assault Systems. Written in the C++ programming language, CATIA is the cornerstone of the Assault Systems product lifecycle management software suite.

DESIGN PROCEDURE

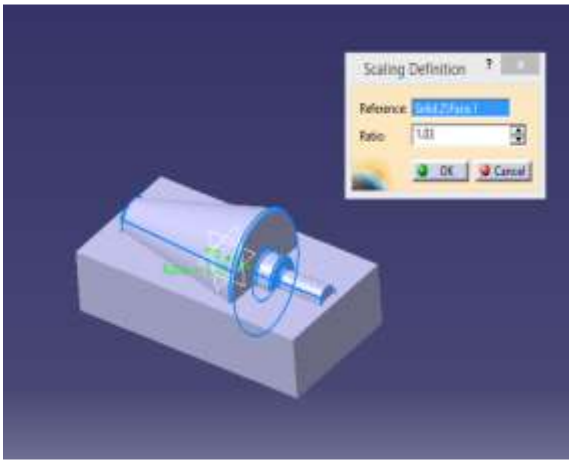
Sketch drawing:draw the skecth in 2d

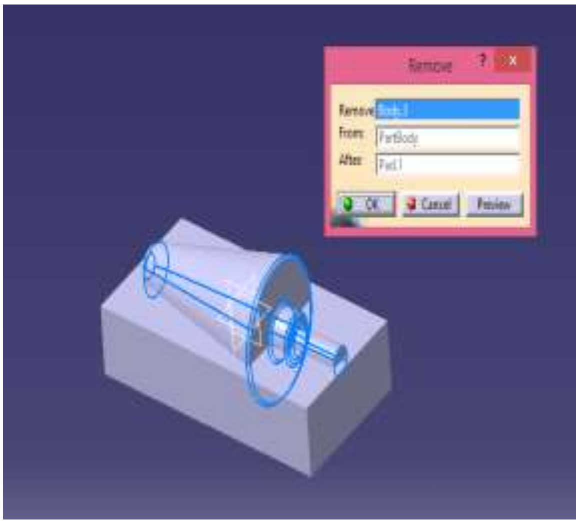


Covaretd to 3d model

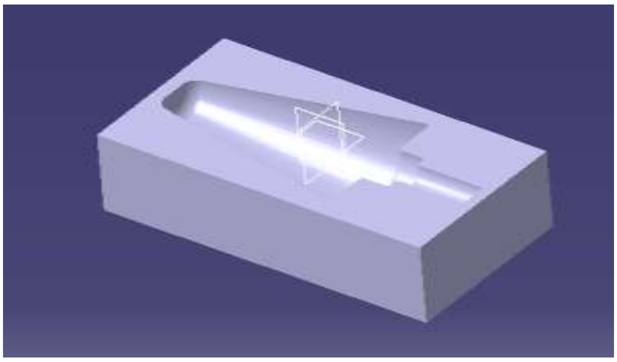


To creating the pattern





Final model:



4. ANSYS

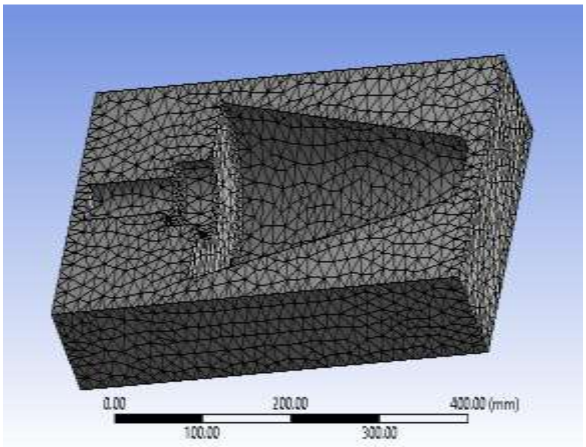
ANSYS is a universally useful limited component demonstrating bundle for numerically tackling a wide assortment of mechanical issues. These issues include: static/dynamic auxiliary examination (both direct and non-straight), warm exchange and liquid issues, and in addition acoustic and electro-attractive issues.

4.1 ANALYSIS OF RESULTS

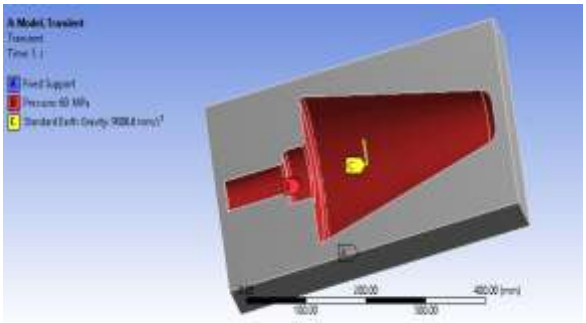
ANSYS

- **Material Data**
  - **EN AC-44300 alsi12 fe**

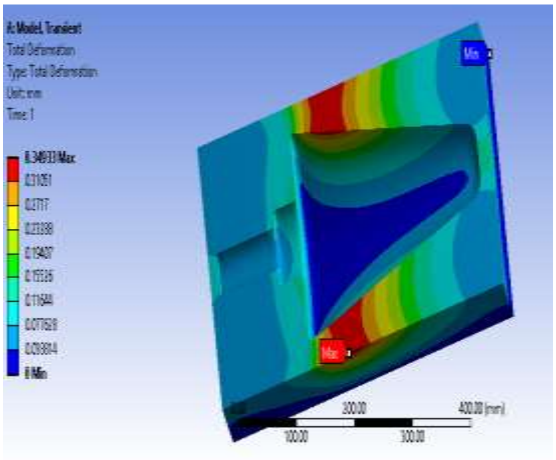
Mesh



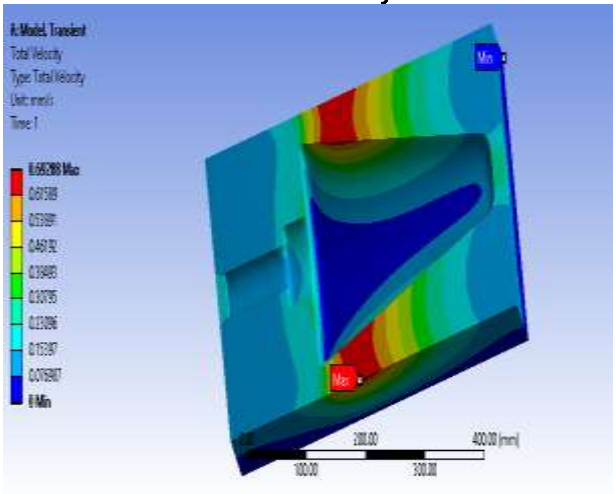
Transient



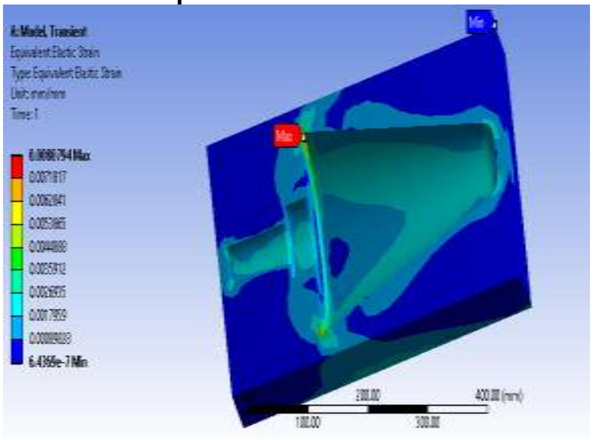
Total Deformation



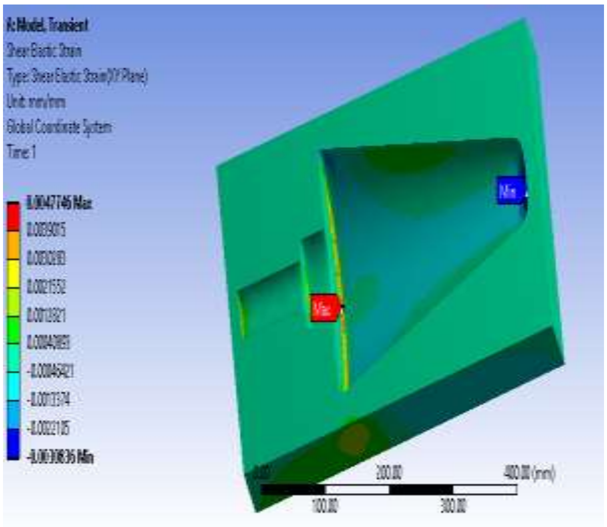
Total Velocity



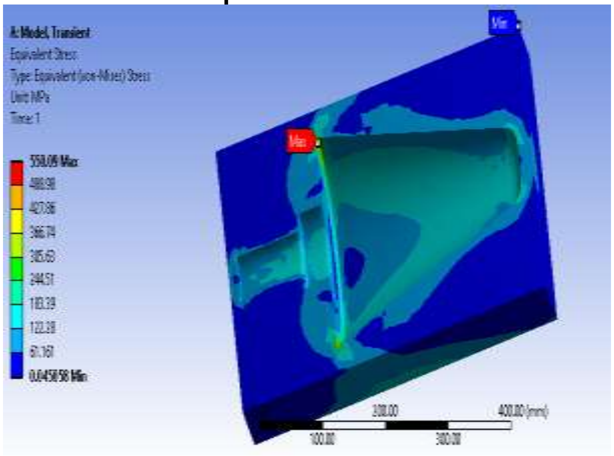
Equivalent Elastic Strain



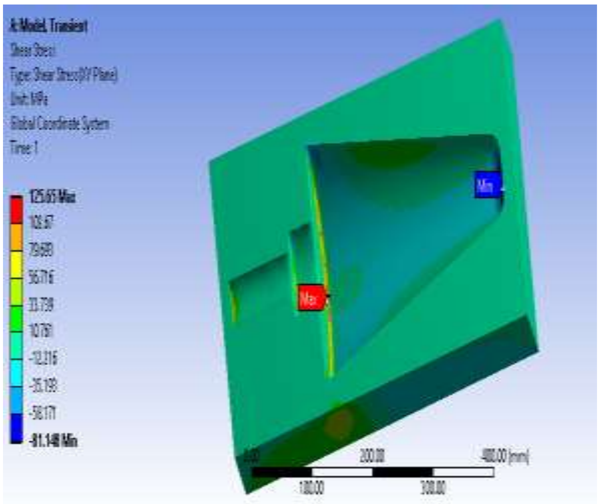
Shear Elastic Strain



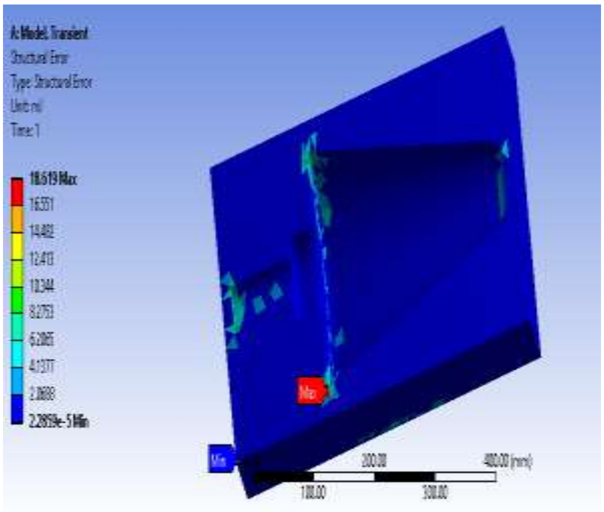
Equivalent Stress



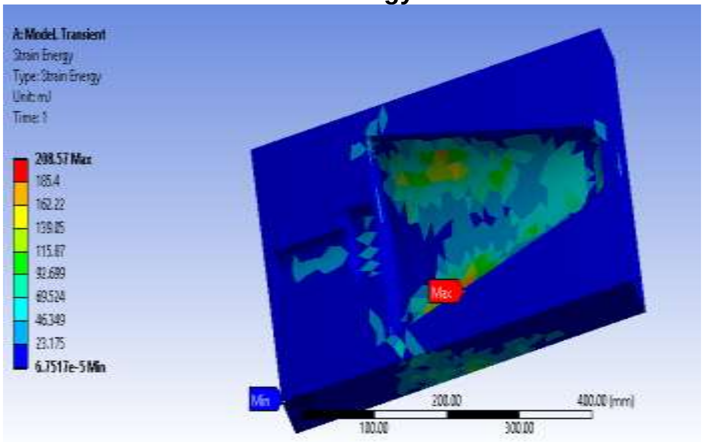
Shear Stress



Structural Error

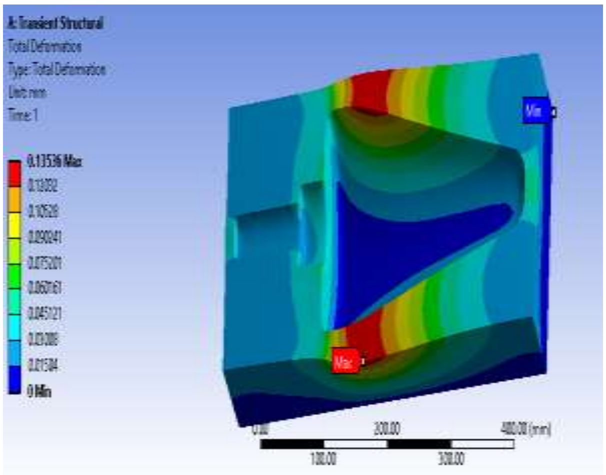


Strain Energy

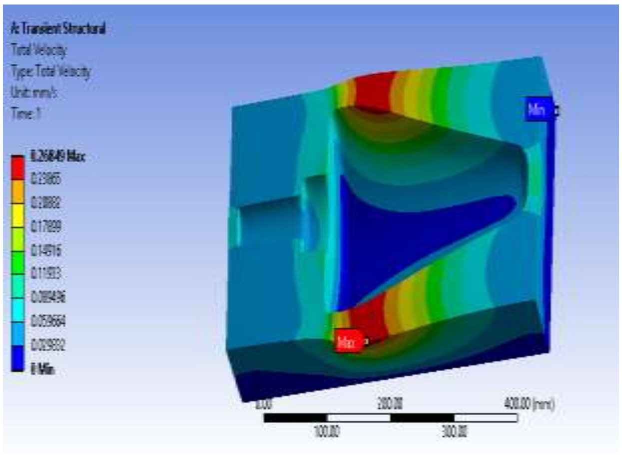


- **Material Data**
  - **NICU30FE**

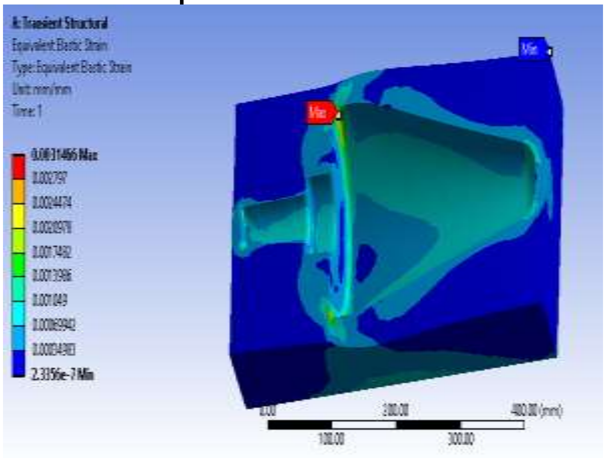
Total Deformation



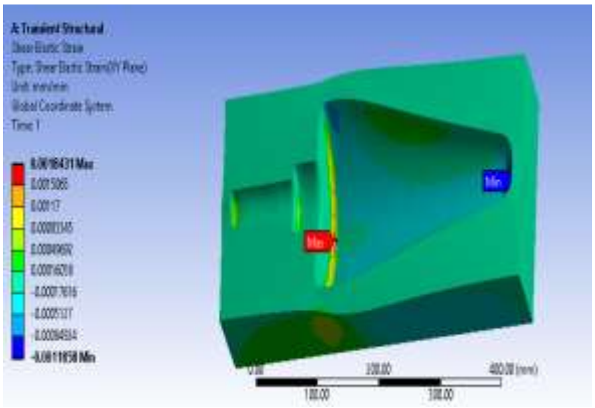
Total Velocity



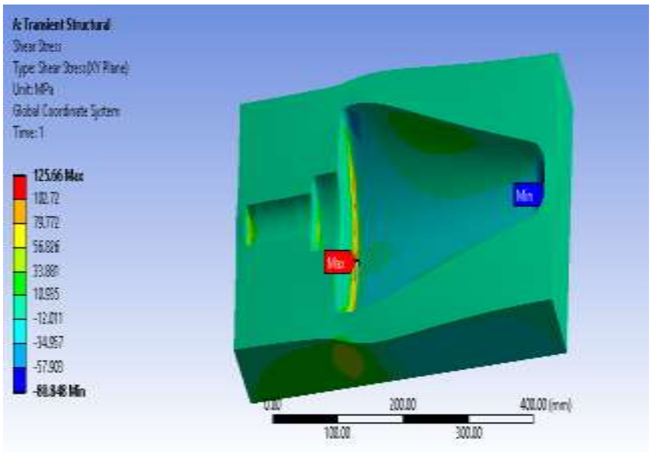
Equivalent Elastic Strain



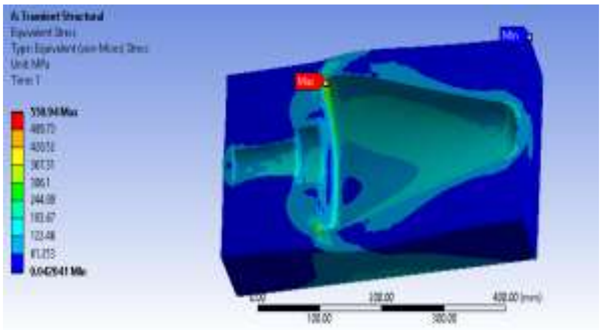
Shear Elastic Strain



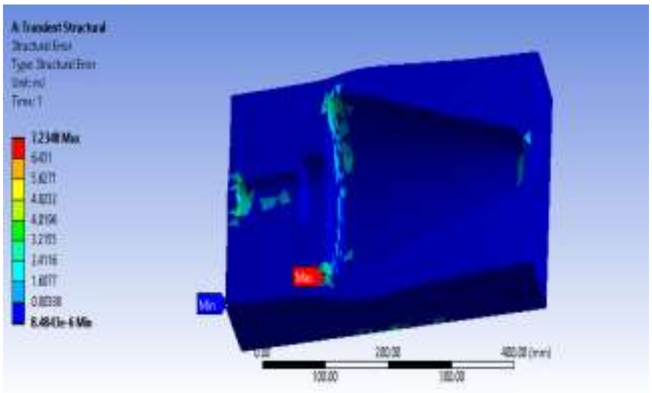
Shear Stress



Equivalent Stress



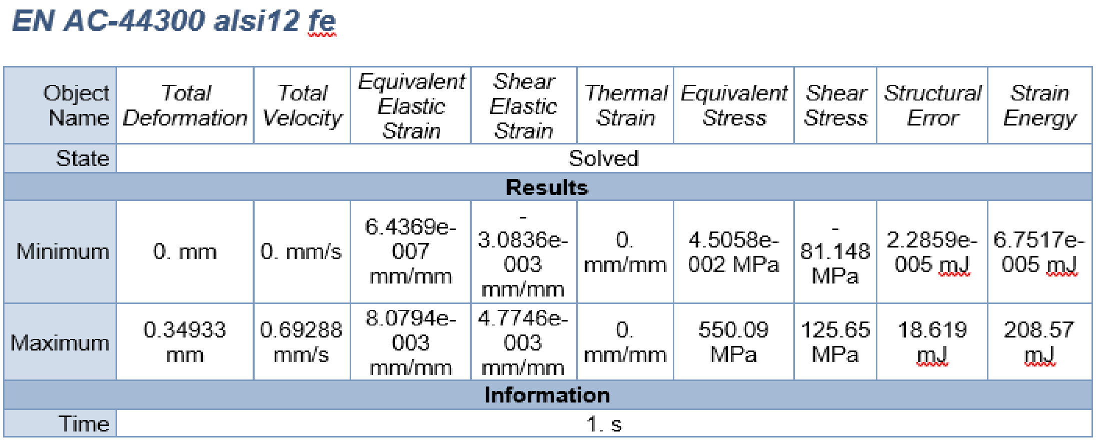
Structural Error



RESULTS

NICU30FE

Object Name	*Total Deformation*	*Total Velocity*	*Equivalent Elastic Strain*	*Shear Elastic Strain*	*Thermal Strain*	*Equivalent Stress*	*Shear Stress*	*Structural Error*	*Strain Energy*
State	Solved								
Results									
Minimum	0. mm	0. mm/s	2.3356e-007 mm/mm	-1.1858e-003 mm/mm	0. mm/mm	4.2041e-002 MPa	-80.848 MPa	8.4843e-006 mJ	2.5027e-005 mJ
Maximum	0.13536 mm	0.26849 mm/s	3.1466e-003 mm/mm	1.8431e-003 mm/mm	0. mm/mm	550.94 MPa	125.66 MPa	7.2348 mJ	80.454 mJ
Information									
Time	1. s								



EN AC-44300 alsi12 fe

Object Name	*Total Deformation*	*Total Velocity*	*Equivalent Elastic Strain*	*Shear Elastic Strain*	*Thermal Strain*	*Equivalent Stress*	*Shear Stress*	*Structural Error*	*Strain Energy*
State	Solved								
Results									
Minimum	0. mm	0. mm/s	6.4369e-007 mm/mm	-3.0836e-003 mm/mm	0. mm/mm	4.5058e-002 MPa	-81.148 MPa	2.2859e-005 mJ	6.7517e-005 mJ
Maximum	0.34933 mm	0.69288 mm/s	8.0794e-003 mm/mm	4.7746e-003 mm/mm	0. mm/mm	550.09 MPa	125.65 MPa	18.619 mJ	208.57 mJ
Information									
Time	1. s								

CONCLUSIONS AND FUTURE WORK

The research was devoted to modelling die casting process in order to predict the final casting shape. In order to achieve this goal, a simulation model was built to model the die casting process. Suggestions for research continuation and future work are also presented.

The conclusions are given for the simulation modeling The simulation modeling conclusions are related to the modeling techniques used in the analysis, the effects of different factors on the simulation results and comparison between the casting distortion predictions

A coupled finite element model was created to simulate the die casting process in order to predict casting distortion and residual stresses. Three material models were used to evaluate the effect of the selected material model on the simulation output. The following are the conclusions from the analysis of the simulation results:

- Most of the residual stresses in the casting are formed inside the die while the casting is restrained by the die steel. After ejection, and during cooling to room temperature, the residual stresses decrease and the casting relaxes to some extent. The amount of relaxation predicted by the simulation depends on the material model used.

- Using the elastic material model to simulate the mechanical behaviour of the casting overestimates the predicted residual stresses. The elastic-plastic material model shows much less stresses than the elastic one. The EN AC-44300 alsi12 fe material model predicts the lowest values of residual stresses. Using the EN AC-44300 alsi12 fe material models is increasing widely in the area of casting modeling, but the unavailability of the required material properties for aluminum alloys eliminates the efficient use of this model in die casting at present.

Future work

The research studied modelling the die casting process in order to predict the casting distortion. The research provided insights to different modeling techniques and criteria. The research also provided experimental work to verify and validate the simulation model. Several modifications can be added to the model to enhance its predictions:

- Modeling the rest of the machine parts. Adding more machine parts to the model will facilitate better solutions. An example for the parts that can be added is the rear platen and the toggle system.

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